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Endogenous Cartel Formation: Experimental Evidence*

Miguel A. Fonseca and Hans-Theo Normann

August 2014

Abstract: In a Bertrand-oligopoly experiment, firms choose whether or not to engage in cartel-like communication and, if so, they may get fined by a cartel authority. We find that four-firm industries form cartels more often than duopolies because they gain less from a hysteresis effect after cartel disruption.

Keywords: cartels, collusion, communication, experiments, repeated games.

JEL Codes: C7, C9, L41

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1. Introduction

Conventional wisdom in industrial economics has it that collusion is easier the fewer the firms. This tenet is intuitive enough: fewer firms will find it easier to coordinate on a collusive outcome or on some punishment mechanism. The conventional wisdom can also be rigorously derived in a repeated game where cooperation is an equilibrium of the supergame, but, the more firms there are in the market, the more patient they must be to sustain a collusive equilibrium.[1]

Despite its popularity on "lists of factors facilitating collusion," it turns out the conventional wisdom is not useful for cartel detection. Empirical studies about factors that predict the frequency of detected cartels do not report favorable results. Among others, Levenstein and Suslow (2006) cannot establish a simple correlation between cartel frequency and concentration or the number of firms.

Why are there not more cartels the fewer the firms in the industry? The decision to establish a cartel should foremost depend on the gains and costs from cartelization. The costs include fines if caught by an authority and, importantly, the opportunity cost in terms of the foregone profits when firms do *not* talk. If collusion is easier with fewer firms, this will also be true under (legal) tacit collusion (Ivaldi et al. 2003), suggesting relatively high profits already without explicit cartel talk. However, if firms do well without talking, why should they risk fines and prison sentences for a little extra profit from price fixing?[2]

This paper illustrates in a simple laboratory experiment how the incentives to form cartels depend on the number of firms. We study industries with two and four firms. The firms can choose to set up a cartel, but a cartel authority randomly audits markets and imposes fines on cartels. In previous research (Fonseca and Normann 2012), we exogenously imposed whether or not firms could talk. There was neither a choice to communicate nor a cartel authority that

[1] See Kühn (2012) for a model where, exceptionally, market fragmentation facilitates collusion.

[2] Levenstein and Suslow (2006) mention this and other possible reasons why there are not more cartels with fewer firms. Davis and De (2013) find many larger number and asymmetric industries in their dataset of EU cartels and argue that ringleaders stabilize these cartels.

would penalize such behavior. Comparing profits with and without the opportunity to talk, we found that medium-sized firms gain the most from communication. We extend this research by endogenizing cartel formation.

Our data indicate that the duopolies form fewer cartels than the four-firm oligopolies, in an apparent violation of the conventional wisdom. This is because of a hysteresis effect: after talking once, industries maintain prices that are higher than before the first cartel was set up. This hysteresis effect is more pronounced for duopolies. Therefore, two-firm markets are under less pressure to set up a cartel anew.

2. Experimental Design and Procedures

Our computerized experiment implemented Bertrand oligopolies with inelastic demand and zero marginal costs of production (Dufwenberg and Gneezy 2000). There were m=300 simulated consumers whose reservation price for a homogeneous good was 100. Subjects simultaneously selected a price *p* between 0 and 100, and whoever set the lowest price captured the entire market and earned profits of 300p; if more than one subject set the lowest price, profits were split equally among those subjects; all other subjects made zero profits. Our treatment variable was the number of firms: N=2 or N=4.

There was a minimum of 25 periods in our experiment. After the 25th period, the computer stopped the experiment with a one-in-six chance (which was common knowledge, as per the instructions). Subjects remained fixed in groups of two or four, for the whole experiment.

Firms could choose to initiate a chat box that got activated only if all firms chose to do so. If so, all firms in the market could communicate for 30 seconds before the price-setting stage and the chat box continued to be available in the following periods until the cartel was detected or until the end of the supergame.

Following several leniency experiments (Apesteguia et al. 2007, Hinloopen and Soetevent 2008, Bigoni et al. 2009), the computer audited each market every

period with probability 0.15. If a market was audited and firms were caught communicating in period t, $100p_t/N$ is the per-firm, per-period fine. Firms were fined for the past periods in which they were talking, up to a maximum of five periods. Formally, the total fine per firm is $F_t = \frac{100}{N}\sum_{\tau=\theta}^{t} p_\tau$, where p_τ is the price in period τ, $\theta = \max\{t-5, t_0\}$, and t_0 is the cartel's initial communication period. Since the fine for the entire industry was evenly distributed among firms, for any cartel price the (expected) fine was the same for N=2 and N=4.

We have 16 independent markets for each treatment. The experiments were conducted in July 2012 and July 2013 at the DICE-Lab of the University of Duesseldorf. Participants were students from all over campus. Sessions lasted less than an hour. The experimental currency was the "Taler," whose exchange rate to euro was 1:15,000 and 1:30,000 in the four-firm markets and the duopolies, respectively. The average payment of the 96 participants was €13.34.

3. Results

We first analyze cartel formation. The N=4 markets successfully formed nearly twice as many cartels: we find 2.19 (std. dev. = 1.22) cartels for the N=4 industries on average versus 1.13 (0.62) for N=2, a highly significant difference (Mann-Whitney (MW) test, p=0.003, two tailed). The result is surprising since getting a consensus to chat is harder with bigger groups. When we count each instance in which at least one firm chooses to initiate the chat (possibly unsuccessfully so), the N=4 markets exhibit significantly more attempts to form a cartel (8.25) than the duopolies (2.94) (MW test, p = 0.001). Thus, despite a lower proportion of successful attempts, more cartels are established with N=4.

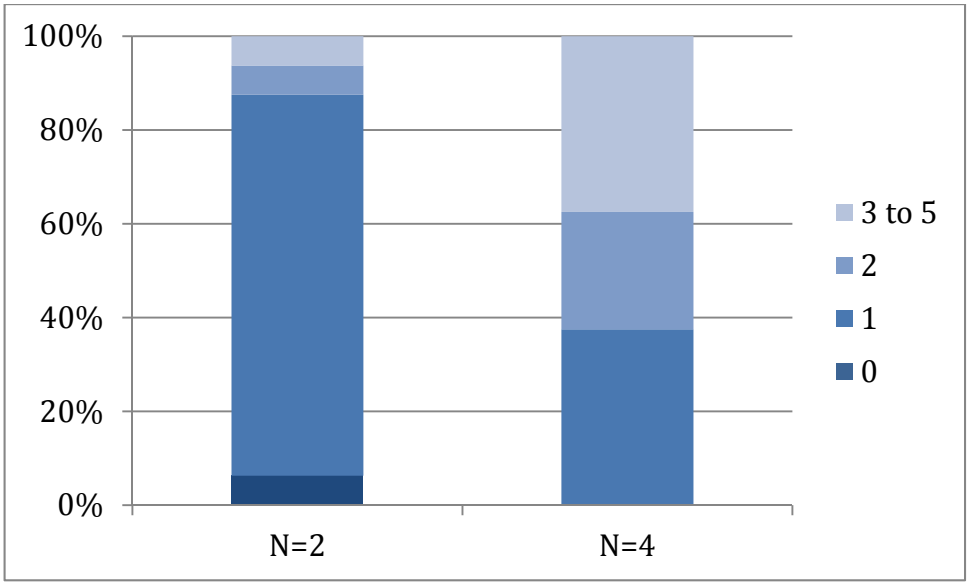

Figure 1. The distribution of the number of cartels formed per market.

Figure 1 shows the distribution of the number of cartels per market by treatment. The vast majority of duopolies talked exactly once (there was even one N=2 market where players never talked and nevertheless performed well), one duopoly started two cartels and another one three. By contrast, 10 of the 16 N=4 markets started more than one cartel.

	Average selling price		
	all periods	when talking	when not talking
N=2	83.95	88.65	80.80
	(19.36)	(15.03)	(21.09)
N=4	78.63	91.10	68.59
	(14.82)	(12.37)	(25.61)

Table 1: Average selling prices by treatment, standard deviations in parentheses, calculated from group moments.

Looking for an explanation for this result, we look at selling prices (that is, the lowest of two or four prices, respectively) in Table 1. Duopolies have higher average prices, but the gap is particularly pronounced when the firms do not

talk. Under communication, the duopolies even do slightly worse than the N=4 markets.[4]

Since selling prices are equivalent to profits in our experiment, the gain from talking can be measured by taking the difference of the selling prices with and without communication.[5] We calculate this difference for each market (except for the one duopoly that never talked) and obtain that it is significantly larger for N=4 (Wilcoxon signed-ranked test, p=0.016). In short, duopolies have a smaller incentive to form a cartel.

Selling prices without communication are affected by hysteresis effects.[6] In both treatments, prices after cartel disruption do not decline to the levels prior to the first cartel being founded. For those industries that did not immediately found a cartel, the average selling prices in period one were 34.33 (N=2) and 32.21 (N=4) and are therefore substantially lower than the prices in the right column of Table 1. Also, the price in the period preceding the first cartel formation was 31.50 and 18.43 for N=2 and N=4 respectively, while the price in the period immediately after the first cartel's detection was 83.75 and 77.64 (N=2: p=0.068; N=4: p=0.001, Wilcoxon signed-rank test). The vast majority of markets formed their first cartel in the first three periods of the experiment; therefore most pricing decisions without communication occurred after a cartel was detected. When we distinguish the two cases, we obtain practically the same result, so we report the mixed measure here for simplicity. We reiterate, however, that the high level of prices "when not talking" is due to a hysteresis effect.

The hysteresis effect can also be demonstrated when considering selling prices and whether a cartel existed before as explanatory variables for cartel foundation. We estimate a random-effects Probit regression using as the regressor a dummy variable taking a value of one if market *j* formed a cartel in

[4] There are no significant time trends of the selling prices, with or without communication.
[5] We do not subtract actual fines here (which would yield the cartels' ex-post profitability) because actual fines vary due to randomness of the detection mechanism.
[6] See Harrington (2004) for a model rationalizing hysteresis effects.

period *t*, conditional on a cartel not being active in period *t-1*. The equation we estimate is:

$$Chat_{j,t} = I\{\beta_0 + \beta_1 Quad + \beta_2 Sellp_{j,t-1} + \beta_3 Sellp_{j,t-1} \times Quad + \beta_4 CartelB4 + \beta_5 CartelB4 \times Quad + u_j + v_{jt} > 0\} \quad (1)$$

	(1)		(2)		(3)	
Quad	0.348**	(0.142)	0.006	(0.352)	0.550***	(0.468)
$Sellp_{j,t-1}$					-0.008*	(0.005)
$Sellp_{j,t-1}$ x Quad					-0.007	(0.006)
CartelB4			-2.125***	(0.392)	-1.543***	(0.491)
CartelB4 x Quad			0.873**	(0.437)	0.638	(0.554)
Constant	-1.630***	(0.109)	-0.407	(0.268)	-0.306	(0.391)
Groups, N	32, 720		32, 720		32, 688	
Rho	0.000		0.222†		0.539†	
Log likelihood	-188.747		-153.608		-120.622	

†: significant at the 1% level using LR test.
***, **, *: significant at the 1%, 5% and 10% level.

Table 2: Probit estimates of the likelihood of starting a cartel.

The regression results are as follows. Specification (1) is a restricted version of our econometric model in order to avoid dropping the first period from the data (nine duopolies and two four-firm markets began cartels in period 1). Consistent with the above results, we find that N=4 markets are more inclined to form cartels. In specification (2), we consider the effect of having had a cartel in existence before the decision to start a new cartel (*CartelB4*). The history of collusion in a market matters differently for different market structures: duopolists are significantly less likely than their four-firm market counterparts to start a cartel if they had colluded explicitly before. Interestingly, the coefficient on *Quad* is now non-significant. In specification (3), we also consider the effect of the selling price in the previous period ($Sellp_{j,t-1}$). The effect of past prices is negative. The higher prices were in the previous period, the lower the odds of forming a cartel. Four-firm markets are more likely to engage in cartels than duopolies and *CartelB4* continues to be highly significant.

4. Discussion

We find more endogenously founded cartels in experimental Bertrand markets with four firms than with two. Markets with four firms have a bigger incentive to cartelize, as a comparison of selling prices suggests. Whereas enabling cartel-like communication leads to significant increases in prices, breaking a cartel does not lead to the opposite result – hysteresis. This is particularly pronounced for duopolies, which consequently are less likely to re-start a cartel after being caught by the cartel authority.

Our result is at odds with the conventional wisdom, if interpreted as "there are more cartels the fewer the firms." In our data, duopolies have higher prices throughout, so the conventional wisdom that "fewer firms find it easier to maintain high prices" does hold both when firms talk and when they do not talk. But we also saw that the gain from talking is larger for the less concentrated industry, and, as a result, "there are fewer cartels the fewer the firms."

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Instructions

Hello, and welcome to our experiment. Please read these instructions very carefully. The experiment will be conducted anonymously, meaning that you will not know with which persons you are interacting. We will not save any data in connection with your name.

Through your decisions and the decisions of the other participants, you may stand to earn Taler. At the end of the experiment, we will immediately exchange your Taler at a rate of

30,000 Taler = 1 Euro

which you will receive cash in hand. We ask you to remain in your booth until we call you to collect your payment. When you collect your payment, please have to hand all the documents you have received from us.

We kindly request that you remain silent during the entire experiment; if at any point you require assistance, please raise your hand and we will come to you.

Firms and markets

In this experiment you will be in the role of a firm which is in a market with another firm. During the entire experiment, it will always be the same firms (or participants) serving a market. That is, you will always be together with the same firm in the market.

The firms produce a good and there are no costs of producing this good.

This market is made up of 300 identical consumers, each of whom wants to purchase one unit of the good at the lowest price. The consumers will pay as much as 100 Taler for a unit of the good.

The firms' profits depend on the prices set by the two firms. In particular, the firm who sets the lowest price will sell to all 300 buyers. The other firm will not have any customers left to supply and will therefore make zero profit. If both firms set the lowest price, they will then equally divide the available consumers.

Let us go over a couple of illustrative examples:

1. Firm A sets a price of 85 and firm B chooses a price of 75. Firm B has set the lowest price and therefore sells its 300 units first at a price of 75, making a profit of 22,500 Taler. Firm A will therefore not supply any customers, thus making 0 Taler.

2. Firm A and firm B both set a price of 70. Given that firms A and B have set the same price, they will have to share the available customers equally. Hence, both firms will sell 150 units at a price of 70 each per unit, therefore making a profit of 10,500 Taler.

Communication

At the beginning of the first period, all firms will be asked whether they wish to communicate with each other before setting the price.

If both firms agree to communicate, a text box will appear on the screen for 30 seconds before firms can set their prices. Firms can communicate about anything they wish, so long as they do not identify who they are in the room. (Abusive language will not be tolerated.)

Payment for communication

If firms decide to communicate, they will have to make a payment with a **15%** probability. A random computer draw will decide whether a payment has to be made. If not all firms decide to communicate with each other, no payment will have to be made.

The payment is determined by the lowest price charged up to five periods back. If the communication started less than five periods back, then only the periods where you communicated will be charged. To summarize:

Payment = 50 x the sum of the lowest prices since the start of communication, but not more than for the last 5 rounds, with a 15% probability.

Consider again our examples. If in Example 1 firms decided to communicate before setting the prices and if the payment has to be made according to the random draw, the payment will be equal to 50·75 = 3,750 for each firm. Firm A would make a loss of -3,750 and firm B's payoff would be 22,500 – 3,750 = 18,750 Taler. If the communication was enabled for more periods, the payment would accordingly be larger.

In Example 2, both firms had a price of 70. If the firms decided in favor of communication, the payment to be made after the random draw is 70 · 50 = 3,500 for both companies. Both would earn 10,500 – 3,500 = 7,000 Taler. If communication has been enabled at this price for three periods already, the payment is 3 · 3,500 = 10,500 Taler. Note once again that it is not necessary to make a payment in every period. It occurs with a 15% probability.

Once firms agree to communicate, they will not need to agree again to communicate. Communication will stay enabled up to the point where you have to make a payment. Firms will then have the possibility again to agree on whether they wish to communicate.

Feedback

At the end of each period, you will find out the prices of all the firms. You will also learn how much profit you have made.

Duration

There will be at least 25 periods in this experiment.

After that, the computer will throw a virtual die which will determine the end of the experiment. If a 6 is thrown, the experiment will end; otherwise, another period will take place.

You will be matched with the same participant in every period.

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